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Comparative analysis of atlas-based and manual prefrontal brain parcellation in an ageing cohort

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Introduction

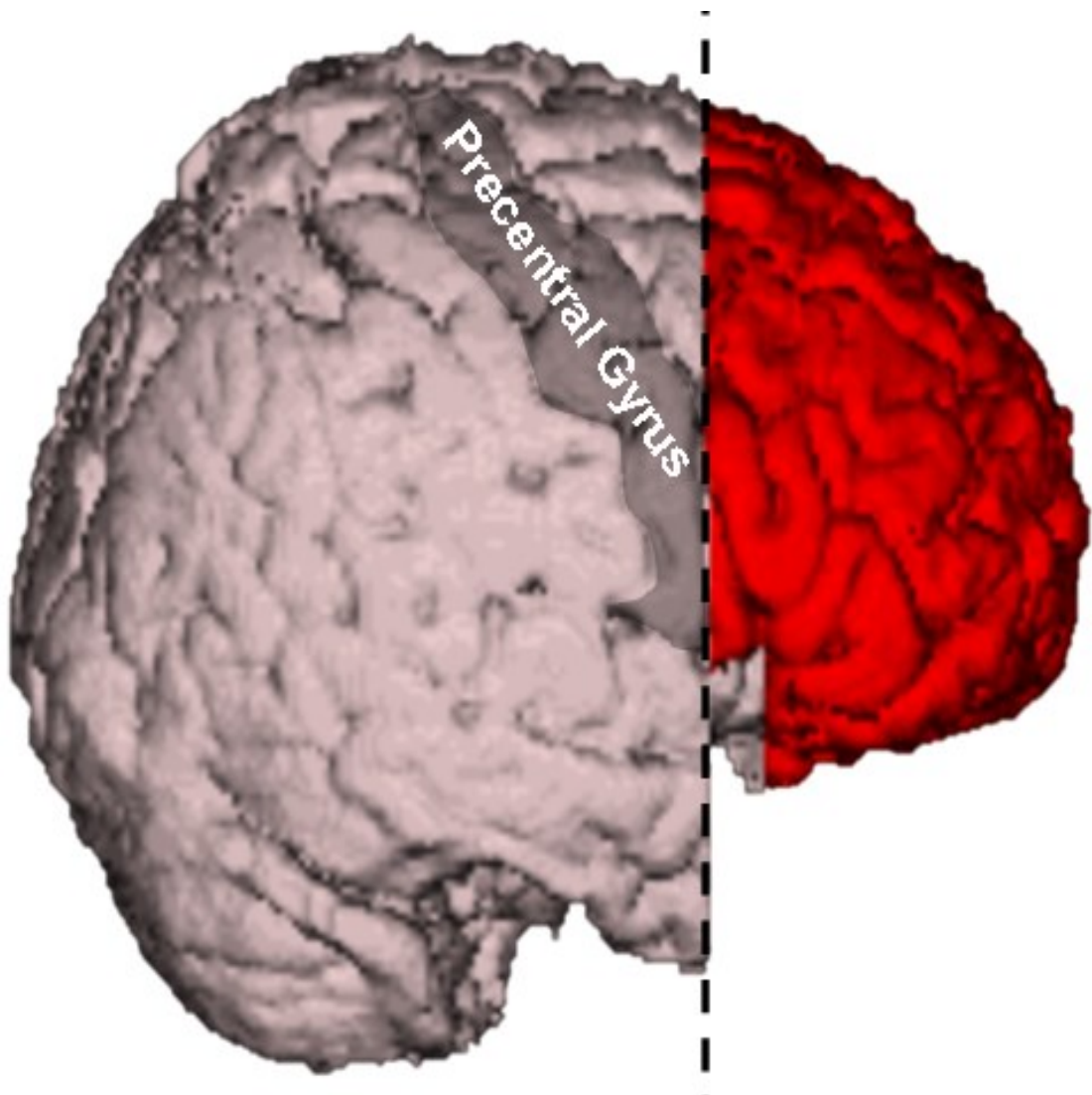
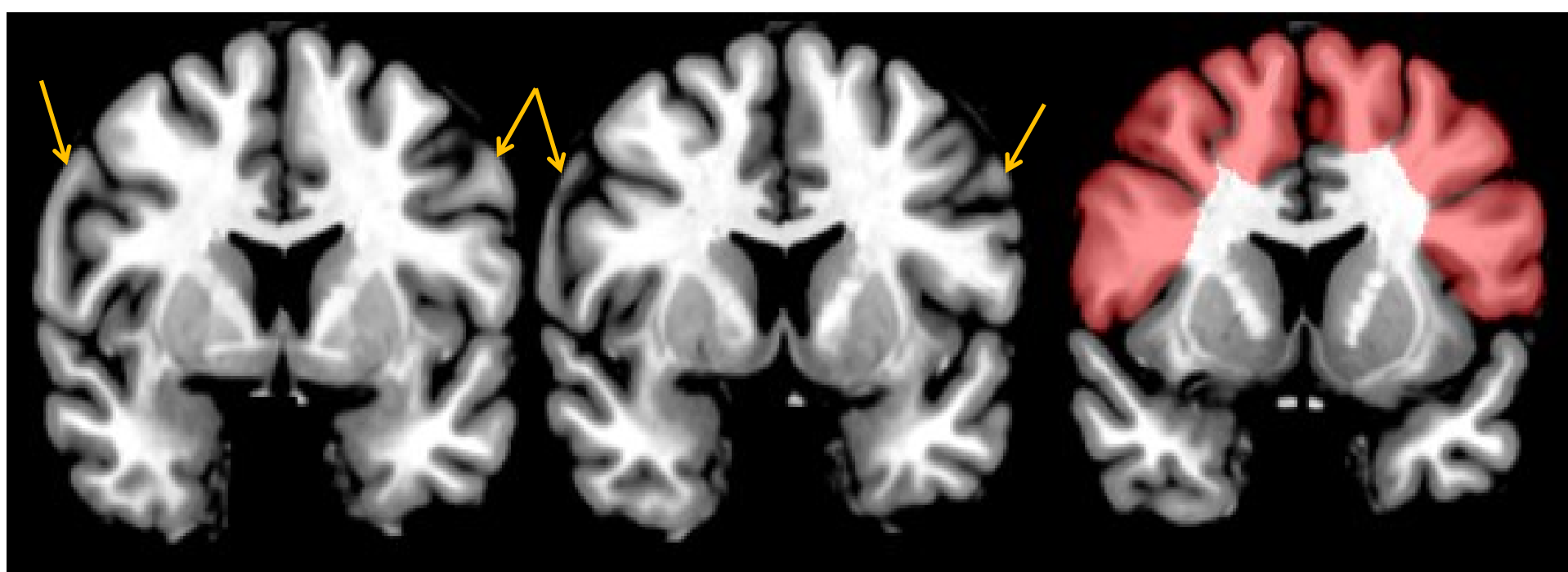
- Regions of interest (ROI) definition is an important step in the analysis of many MR images
- Manual Definition of Region of Interest
 - Time Consuming
 - User Bias and Issues with Reproducibility
- Atlas based Method
 - Requires standardization to normalise variation in brain sizes and shapes
 - Non-linear registration matches boundaries better than linear
 - Single atlas cannot account for anatomical diversity
 - Multi-atlases¹ performs well in young adults

Purpose

- To compare the performance of both single- and multi-atlas parcellation with manual segmentation using brain MRI of older men
- Also to investigate the choice of atlas(es) selection for both single- and multi-atlas approaches

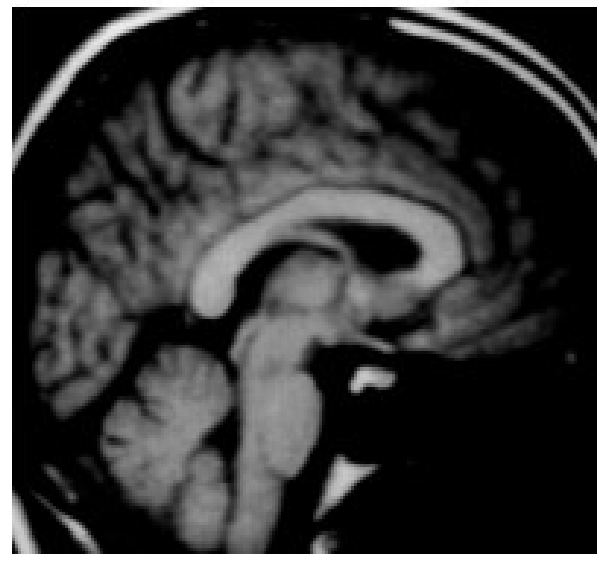
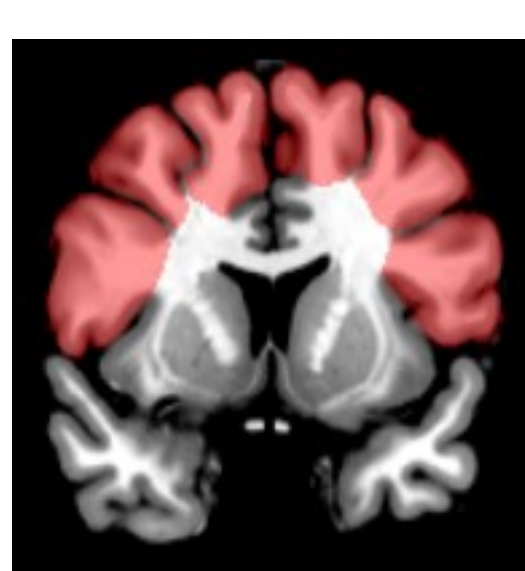
Manual Segmentation

- Frontal gyri segmented anterior to the coronal appearance of precentral sulcus.



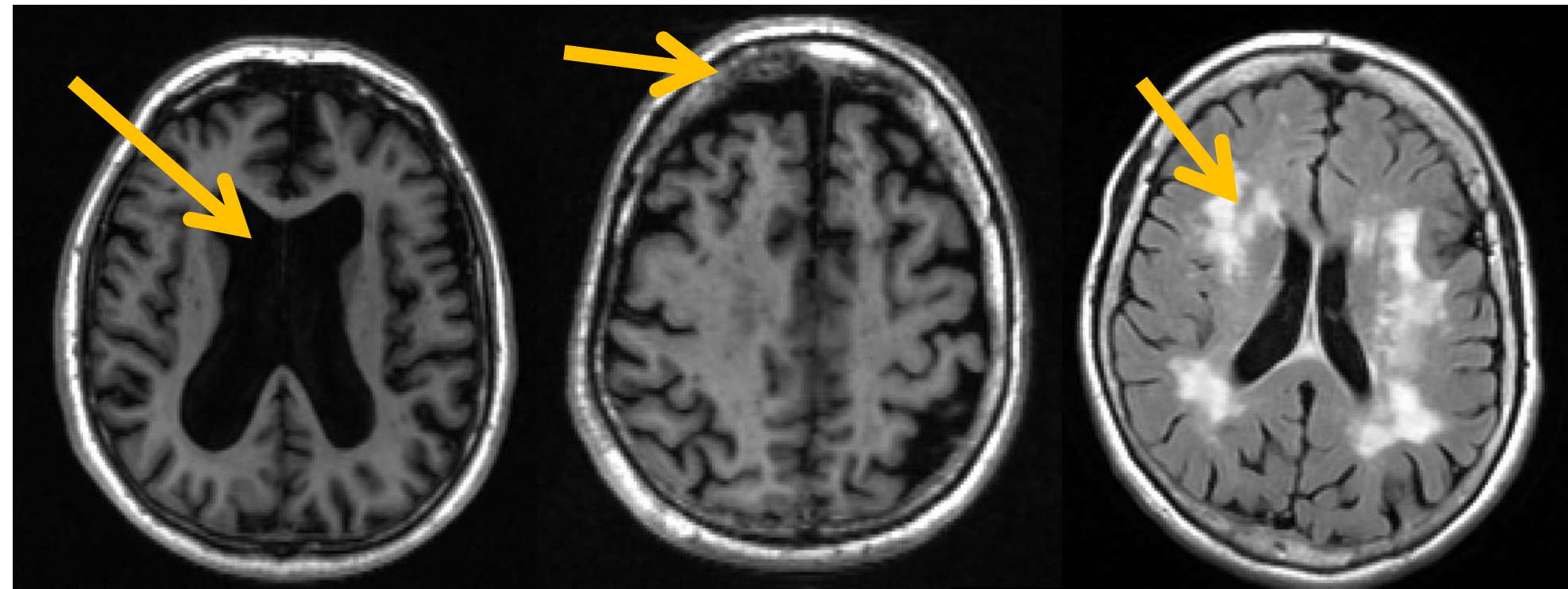
Single Atlas Parcellation

- Representative atlases selected based on:
 - Study-based ageing brains
 - Intracranial volume (ICV)
 - Total Brain volume (TBV)
 - Frontal lobe volume (lobe)
 - Non-study-based brain
 - Young male adult
- Atlases transformation to target brain used ART⁵



Challenge

- Age-related changes pose a significant challenge to any automatic method²
 - E.g. Atrophy
 - Skull Thickening
 - Lesions
- Prefrontal brain
 - High degree of inter-subject sulcal pattern variation
 - Highly susceptible to age-related changes e.g. atrophy
- Performance of atlas based parcellation in ageing has not been investigated

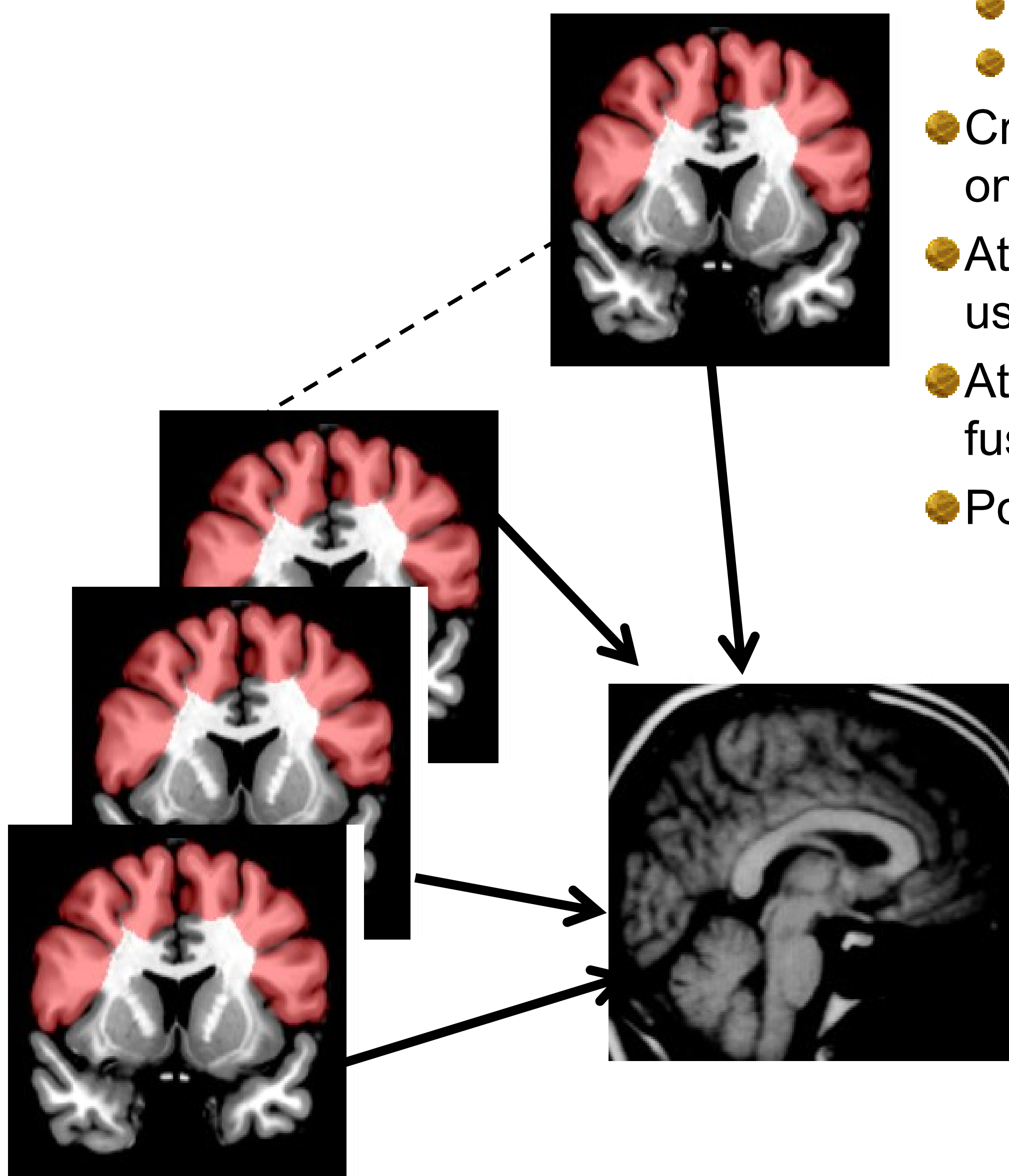


Subjects

- Ninety scans of men selected from 700 members of Lothian Birth Cohorts 1936³
 - Community dwelling, Mean age 72.7+/-0.7 years
 - Non-demented, Non depressed and Not taking any anti-depressant
 - T₁W scan (resolution 1x1x1.3 mm)⁴, 1.5 T GE scanner

Multi Atlas Parcellation

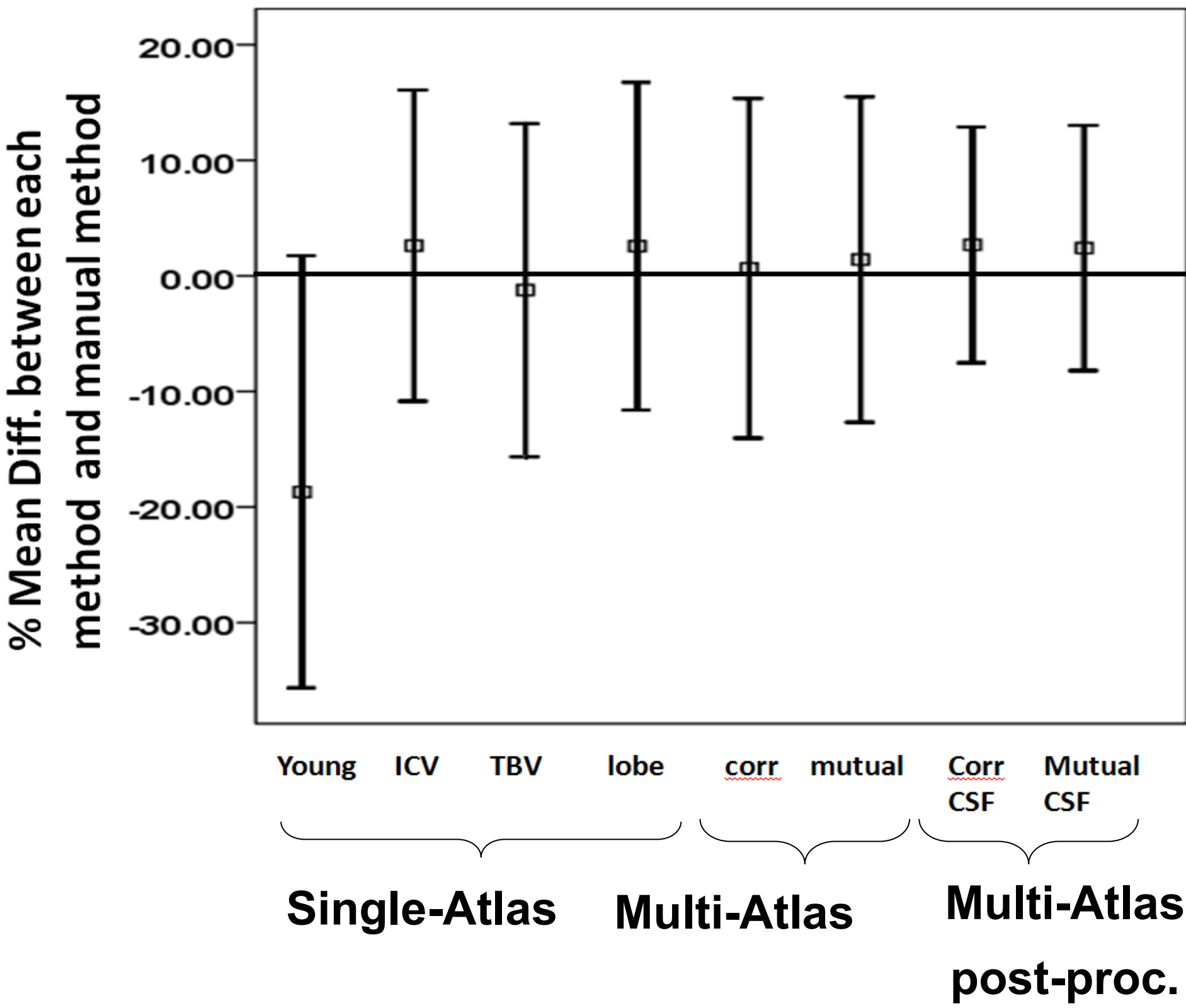
- Atlases selected based on
 - Normalised Mutual Information (mutual)
 - Normalised correlation coefficient (corr)
- Cross validation based on leave-one-out method
- Atlases transformation to target brain used ART⁵
- Atlases combination used image fusion⁶
- Post-processed to remove CSF



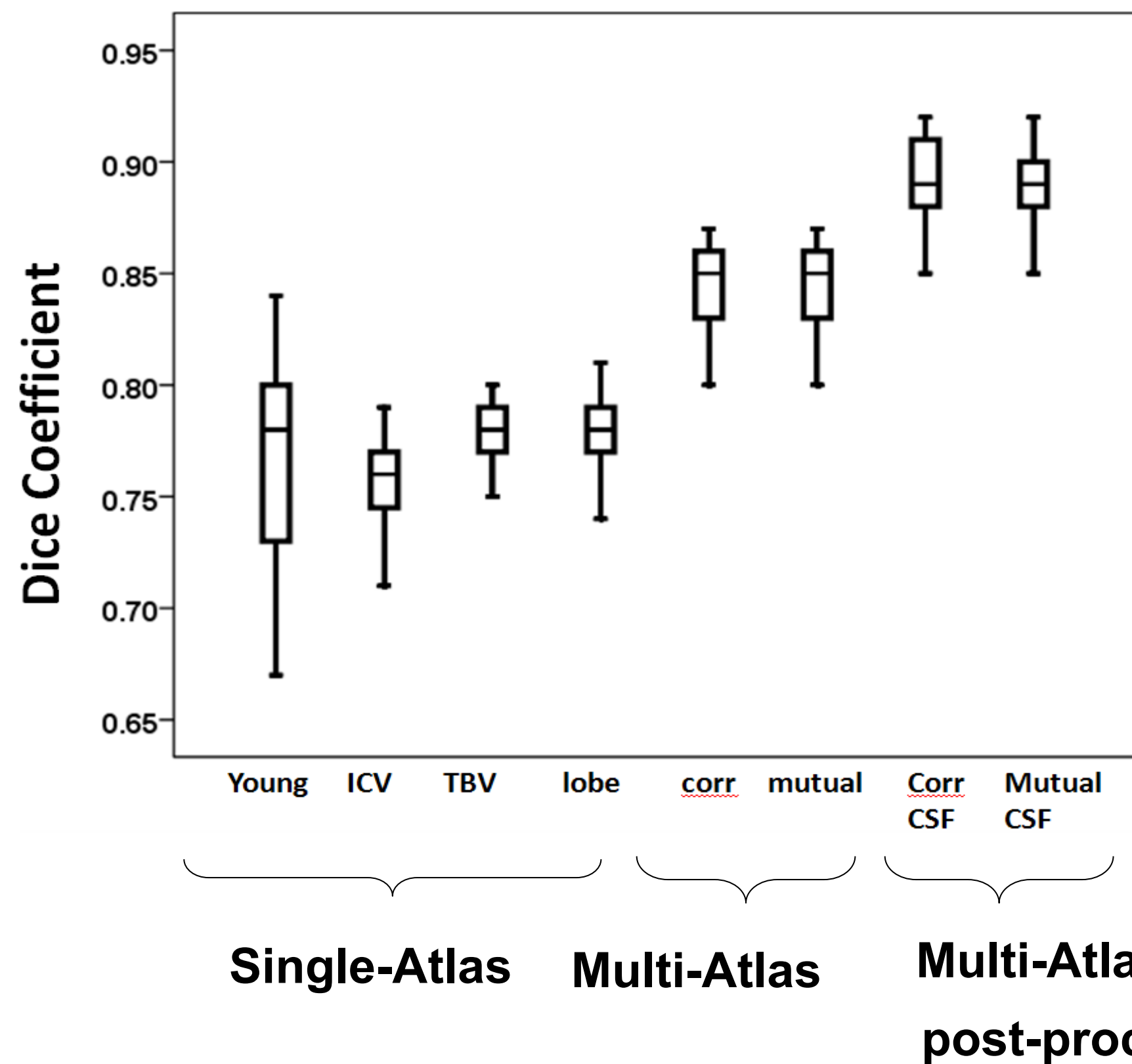
Results

- The atlas based on TBV performed best of the single atlases
- For multi-atlas Correlation and mutual information gave equal performance
- Multi-atlas performed better than single atlas
- CSF removal improved performance

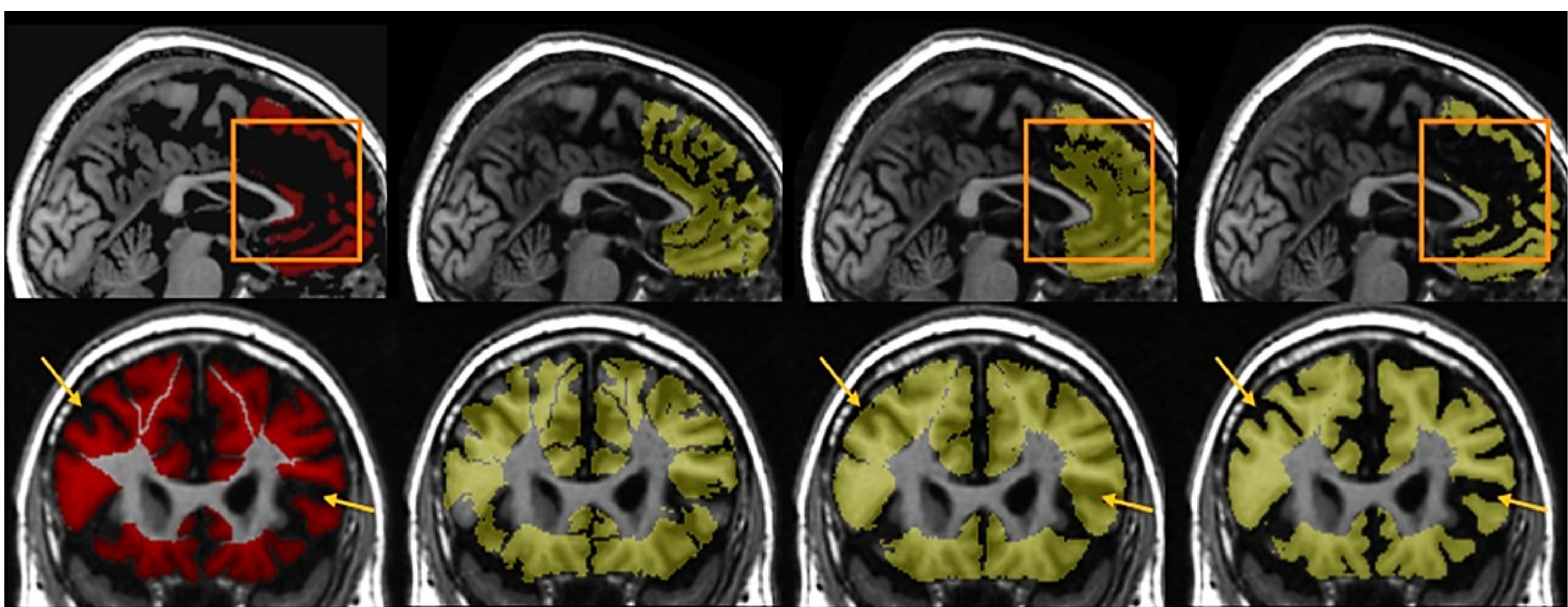
Volumetric: Bland Altman



Spatial Comparison: Dice Coefficient



Visual Assessment



Manual Single-Atlas Multi-Atlas Multi-Atlas post-proc.

- Sagittal (top row) and coronal (bottom row) planes.
- From left to right, manual, single-, multi- and multi-atlas after CSF removal
- For single atlas, local patterns of gyrification were not well-matched
- For multi-atlas, prior to CSF removal, voxels in lateral (orange arrows) and medial aspects (orange box) were classified as brain tissue.
- Single-atlas, representative brain selected based on the total brain tissue volume
- Multi-atlas, atlases selection used normalised correlation coefficient

Conclusion

Atlas-based parcellation method performed reasonably well in the ageing men. However, brain shape and particularly the effects of age-related atrophy could reduce its performance, hence there is need for visual assessment and some manual editing. The performance of any parcellation scheme should be assessed, not only by volumetrically, but also visually and by measure of spatial concordance. Future work should investigate incorporating atrophy metric into atlas selection

References

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